VOL. XLVI

NO. 3

# TRANSACTIONS
## OF THE
# AMERICAN FISHERIES SOCIETY

JUNE, 1917

Published Quarterly by the American Fisheries Society
at The Aquarium, New York, N. Y.

Entered as second class matter, December 21, 1914, at the Post Office at New York, N. Y.,
under the Act of August 24, 1912.

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Organized 1870—Incorporated 1910

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# TRANSACTIONS

of the

# American Fisheries Society

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"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

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VOLUME XLVI, NUMBER 3

1916-1917

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Edited by Raymond C. Osburn

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JUNE, 1917

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Published Quarterly by the Society

NEW YORK, N. Y.

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# THE SENSES AND LEARNING IN FISHES*

By Jacob Reighard.

## I. Introduction.

I have often been asked whether fishes can smell or taste or hear, whether they distinguish colors and whether they learn to keep out of nets or to avoid the hook. What workers in science have learned about these matters has been publishd in many languages and in various technical journals and books so that much of it is not easily accessible. In view of the widespread interest it has seemed to me worth while to bring together what is known to put it in non-technical form and to let it be printed, so that all may have access to it. I shall not try to point out all the uses that may be made of this accumulated knowledge—but those who have to do with fish will, I trust, see that they may at any time have need of it.

I shall speak of the senses and of learning in fish. But there are many kinds of fish, more than 12,000 in North America alone. They differ much in the structure of their sense organs, and probably much in capacity to use them and to learn. Very few kinds have been investigated by scientific men. When, then, I say that fish do thus or so, it should be remembered that the statement is usually based on studies of one or two kinds only. That other kinds have the same capacity as those investigated is an assumption, more or less warranted. Those who wish to know what kinds of fish have been studied should consult the literature list (p. 166), referred to throughout this paper by means of date numerals following the names of authors.

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*Address of the President of the American Fisheries Society at the New Orleans' meeting, October 18, 1916.

## II. THE SENSES OF FISHES.

The sense organs of animals are sometimes divided into two groups—*surface receptors* which take note of objects in contact with them and *distance receptors* which are affected only by vibrations or emanations from distant objects. Amongst fishes the organs of touch, temperature and taste are surface receptors while those of smell, hearing and sight are distance receptors. Besides these senses fishes have another not possessed by man and to be presently referred to.

A. THE SENSES OF TOUCH AND TEMPERATURE need not long detain us, for we know but little about them in fish. Parker (1910b), has shown that when the salt water dogfish (*Mustelus canis*), is touched in particular regions of the body there result corresponding movements of the fins or other parts. These are such as either to turn the animal away from the object touching it or to brush away the irritation or to close the cloacal opening or the eye. The fish has therefore a sense of touch over the whole surface, and by means of it is able to locate with some accuracy objects that come into contact with it and to make the movements necessary to avoid injury from these objects.

That fish are very sensitive to slight differences in the temperature of the water is known from the work of Shelford (1915). He arranged long troughs in which the water at the middle was of intermediate temperature, while it became gradually warmer toward one end and colder toward the other. Fishes were introduced into the middle of the trough and could then swim toward either end. Each kind showed preference for water of a certain temperature and when, in swimming along the trough, it encountered water of different temperature it tended to turn back. By noting the point in the trough at which various fish turned Shelford found that a difference in temperature of as little as five-tenths of a degree centigrade might cause the turning. He believes that fishes are sensitive to temperature differnces as little as two-tenths of a degree centigrade. Michael (1908), has

collected evidence to show that movements of schools of minnows in small inland lakes may be due to slight inequalities in the temperature of the water. In this connection it may be suggested that the temperature of the water may have much to do with directing the movements of fishes to their spawning grounds.

B. THE SENSES OF TASTE AND SMELL are best considered together although the organ of the first is a surface receptor, that of the second a distance receptor. Yet both organs serve to make animals aware of chemical differences in substances.

In man substances must be taken into the mouth in order to be tasted. Liquids and the liquid parts of such things as meat then come into contact with the taste organs while solids reach these organs after being dissolved by the fluids of the mouth. Whatever we taste is therefore in solution. From these things we get but four sensations of taste, sour, sweet, bitter and salt. So long as we are breathing through the nose the odors of food substances are carried from the back of the mouth by the outgoing breath and so enter the cavity of the nose at the back and affect the organ of smell. We then think that we are merely tasting what is in the mouth and we get the impression that our foods have more taste qualities than sour, salt, bitter and sweet. In reality we both taste and smell the food under these circumstances. We perceive whatever taste qualities the food may have and at the same time we perceive its odors. The odor sensations thus perceived we call taste sensations and we seem to have many more than four qualities of taste. But if the nose be held so that no breath passes through, it is impossible to smell. We then get but the four taste qualities even though we put into the mouth many substances of very different odors. We thus learn that qualities other than bitter, sweet, sour and salt are perceived by the sense of smell, not by that of taste.

In order that we may smell a thing, an emanation from it—gas or vapor—must be carried in the air and enter the nose with the breath. At first sight it seems that we

may distinguish between taste and smell on the ground that taste is concerned with substances in liquid solutions while smell has to do with gases and vapors. But we now know (Parker and Stahler, 1913), that the gases and vapors that affect our sense of smell are first dissolved in the fluid that moistens the lining of the nose. Thus both the organs of taste and smell are affected by substances in solution, and there is no difference between them on this score.

But these senses differ in several ways. *First,* the organs of taste are affected by things in contact, that of smell by gases or vapors which come primarily from things at a distance. *Second,* the organs of taste are affected only by substances in relatively concentrated solutions, the organ of smell by substances very greatly diluted. Parker and Stahler (1913), found that pure ethyl alcohol could be smelled when its molecular concentration was only about one twenty-four thousandth that necessary to give a sensation of taste. When quinine, the substance having the strongest known taste, is compared with mercaptan, the substance having the strongest known smell, the difference is still more striking. To give any sensation of taste the quinine must have a molecular concentration 44,000,000 times that of the mercaptan that man is just able to smell. *Third,* while we know but four tastes we perceive a very large number of odors.

In fishes the organs of taste and smell are of course affected by substances in solution, for all things capable of affecting them are dissolved in the water. We may therefore expect these senses in fishes to operate very much as they do in man. Things that fishes taste must be in contact; they are usually tasted and felt at the same time. They must affect the organ of taste in relatively concentrated solution. Things that are smelled may be at a great distance. They are smelled without being touched. Their odorous portions reach the fish through the water and must often be greatly diluted. That there are but few qualities of taste in fishes as in man and

many qualities of smell is probable from the facts now to be set forth.

1. *Taste in fishes.* In man, the organs of taste are situated chiefly on the tongue. In fishes they occur in the tongue, in the lining membrane of the mouth and for a considerable distance back in the throat. But fishes differ from higher back-boned animals in that the organs of taste, or taste buds, occur not only in the mouth but over the outer surface. In the catfishes they are found over the whole outer surface, especially on the barbels. In the codfishes they occur on the body and fins, but are concentrated on the slender pelvic fins, which may be stretched down and forward under the throat. In other fishes they have various situations on the outer body surface (Herrick, 1903).

If a piece of cotton wool, soaked in meat juices, is touched to the side of the tail of a bullhead while his eyes are covered, the animal at once turns and seizes the cotton (Herrick, 1903). He cannot see it but he *feels* and *tastes* it. If the cotton wool is used without the meat juices the fish at first seizes this also, but he soon *learns* to distinguish between the feel of the cotton alone and the feel and taste of the cotton soaked in meat juice. Threafter he pays no attention to the cotton unless soaked in the meat juices. If meat juices are squirted against his side he turns and bites at the nozzle of the syringe. If water alone is used he does not turn, but may move away as though irritated. He pays no attention to pieces of brick touched to the side unless these are soaked in meat juice. The fish then may feel and taste those sapid substances that touch the skin and may attend to them. He feels non-sapid substances, but pays little attention to them so long as they touch him but gently.

It is then clear that a fish may taste substances in contact with the skin as well as those in the mouth. Parker (1912), has found that when salt, sour and alkaline liquids of certain concentrations are squirted gently against the mid-trunk or tail of a bullhead (*Ameiurus nebulosus*), the animal does not turn as though to seize

food, but moves away as though irritated. On the other hand if distilled water only is used the fish is not affected. Quinine does not disturb the fish when applied to mid-trunk or tail, but when applied to the mouth it has the same effect as salt, sour or alkaline. The fish thus acts negatively to three of the four classes of substances (salt, sour, bitter) that affect our organs of taste. To the fourth of these substances it does not respond (sweet). But sugar is not found normally in the fishes' environment, and it is therefore not strange that they do not respond to it.

When the bullhead is touched on the body with a piece of meat it responds positively by turning to seize it, although it may not see it. There is then something in the meat other than salt, sour or bitter that affects the organs of taste of the fish. To this something the fish responds positively, while salt, sour, bitter and alkaline substances seem to irritate so that it responds negatively to them.

Parker (1912), was able to show that when the nerves going to the taste buds in the skin of this fish were cut it no longer responded to pieces of meat but was still affected by salt and sour and alkaline liquids. He concludes that there are two sorts of organs in the skin of this fish—the taste buds affected by certain sapid substances in the meat and the free nerve endings affected by salt, sour and alkaline substances. These two sets of organs are supplied by different nerves. The fish responds positively to those things that affect the taste buds, negatively to those that affect the free nerve endings. Parker would call the sense that takes note of salt, sour and bitter substances the common chemical sense, that which takes note of the sapid substances of meat through the taste buds he would call the sense of taste. The distinction is not maintained in this paper. Results similar to these of Parker were obtained by Sheldon (1909), who worked on the salt-water dogfish (*Mustelus*).

We have seen that the fish tastes three classes of substances that we also taste: salt, sour and bitter. It fails to respond to one sweet substance that affects our taste organs, sugar. It responds through its organs of taste to one substance for which we have no separate sensation of taste, and, although we do not know what this substance is, we may refer to it as a sapid substance in meat. The fish then tastes one substance that does not affect our organs of taste, and there may be other substances that affect its taste organs, but do not affect our own. We do not then know how many substances a fish tastes. We know only that it responds negatively to salt, sour and bitter and positively to meat. We may therefore say that it can tell the difference between meat juice and the salt, sour and bitter substances used—but we cannot say that it can tell salt, sour and bitter from each other—for it behaves in the same way toward all of them.

2. *Smell in fishes.* The organs of smell in fishes are two small sacs located in the snout, one on either side in front of the eye. In most fishes they lie on the upper side of the snout, but in sharks on the lower side. Each has two openings on top of the head (except in sharks), one in front of the other. A current of water, produced in different ways in different fish, enters the anterior of these openings and passes out through the other. But the sacs do not communicate with the cavity of the mouth so that, unlike man, it is probable that fishes are unable to smell things held in the mouth.

The sense of smell in fishes has recently been studied in the bullhead, *Ameiurus nebulosus* (Parker, 1910), in the killifish, *Fundulus heteroclitus* (Parker, 1910, 1911, 1912), in the smooth dogfish, *Mustelus canis* (Sheldon, 1909, 1911; Parker, 1912; Parker and Sheldon, 1913), and in the puffer (Copeland, 1912).

The usual method of experiment has been to prepare two packets of cheese cloth, one of which contains meat while the other does not. These are placed in an aquarium containing several of the fish. If the fish used are of species that do not ordinarily seek their food by sight

(bullhead, dogfish), they may for a time pay no attention to the packets. If they are fishes that habitually seek food by the use of the eyes (killifish), they may at first bite at both packets in the same way. But in either case, as the juices from the meat penetrate into the water, the fish show signs of being stimulated. While the killifish pay little or no heed to the meatless packet they now crowd about that containing meat and bite at it. The dogfish and the bullhead move restlessly about until they finally come into contact with the packet containing the hidden food, when they attempt to seize it.

Water may be prevented from entering the nasal sac of any of these fishes by closing its anterior opening. This may be done by tying a thread about the opening, by stitching its lips together or by filling it with cotton. Fish thus treated show no difference in their behavior toward packets containing meat and those without it. The killifish, which sees the packets, may bite at either packet, but soon ceases to notice them. The dogfish does not become restless and seek about for food. If the obstruction is then removed from the opening of the nasal sac, so that water may pass through it, the fish, after resting for a while, recover their power to tell the packet that contains meat from that which does not. It is thus clear that fish are stimulated by substances emanating from the meat and that these substances affect the olfactory organ. The sense of smell enables the fish to detect invisible food at a distance. How great the distance may be we do not know. Professor Parker records a statement of Mr. Vinal Edwards "that it is the custom in fishing for dogfish to throw out in the tide lines baited with menhaden or alewives. For a time no dogfish will be seen, then they will appear in numbers, swimming around the bait in gradually diminishing circles until finally it is seized." It seems that the dogfish do not see the bait but that they smell it at a considerable distance and that the odorous material carried to them by the water must be very greatly diluted.

When a dogfish seeks hidden food in an aquarium it seems to circle about in a restless, random way until it finally comes upon the food by chance. Its sense of smell does not seem to direct it to the food. But Professor Parker found that if one nasal sac of a dogfish was filled with cotton and the other left open—the fish in seeking food, turned more often in the direction of the open sac. It thus became clear that the nasal organs do more than make the fish aware of the presence of food in its neighborhood; they guide the fish toward unseen food. The fish turns toward that side from which the stronger odor comes out and thus finds the food more quickly.

On the whole the organs of smell in fish serve the same purpose as in man. In both they are sensitive to very minute quantities of substances emanating from distant bodies and not only make the animal aware of the presence of these bodies but direct its course to them. In the fish, as in man, there are probably very many substances that affect the organs of smell.

3. *The need of taste and odor in baits.* The fisherman who would know the use made by the fish of the senses of touch, taste and smell in taking bait, must distinguish two classes of fish. Those that are guided to their food by sight and feed by day may take into the mouth anything of suitable size that attracts attention by its movement. The fish then tastes the bait, and it may be rejected if the taste is not satisfactory and if the fish is not at once hooked. If fish of this group are not to be hooked immediately, if they are to be given time to run with the bait, it seems clear that the bait should not be merely salt, sour or bitter, for these repel the fish. It should contain some "sapid" juice like that of meat.

If the fish do not feed by sight or if the fishing is done at night then again bait should contain some sapid substance that the fish may taste it. It will be more effective if it has also odor. When such odorous bait is put into the water the fish are directed to it by the sense of smell, even in the dark. If they come into contact with it with any part of the body containing taste buds they

taste it and at the same time feel it. The sense of taste then probably tells them whether it is edible while the sense of touch enables them to locate it so accurately that they turn and seize it without seeing it. For fish that do not make much use of the eyes in feeding it is well then if the bait has both taste and odor. As a practical measure it is perhaps well when seeking such fish to avoid baits that seem to us *merely* salt, sour or bitter and without odor and to use those that have odor or that *seem* to have other qualities of taste than salt, sour or bitter. To use a sweetened bait would be unavailing in any case.

C. THE SENSES OF MASS-MOVEMENT, HEARING AND SIGHT. The senses of fishes that take note of vibrations (not emanations), are hearing, vision and another sense not possessed by man. This other sense deals with mass movements in the water either currents (constant movements in one direction), or very slow vibrations, back and forth movements). Hearing is concerned with the more rapid vibrations of the water that are perceived as sounds, while sight is concerned of course with the light waves that traverse the water. The organs of these senses may be said to be distance receptors sensitive to movements, but not to chemical substances.

### 1. *The Sense of Mass Movement.*

Along the middle of each side of the body in most fishes is a peculiar row of scales, those of the lateral line. In each of these is a small opening which leads into a short tube. These tubes terminate in a larger, tunnel-like tube beneath the skin, the so-called lateral-line canal, which runs along the side of the body. This canal extends also on to the head, where it divides into three main branches and communicates with the surface by numerous short tubes, whose openings are easily seen with the naked eye. Within the lateral line canal on head and body are numerous small sense organs, the lateral-line organs. From these nerves extend to the brain. The use of these

organs was long a matter of controversy—but through the work of Professor Parker and others it is now known.

From numerous experiments chiefly on the salt-water killifish (*Fundulus heteroclitus*), Parker (1903, 1903a, 1905, 1910b), concluded that the lateral line organs are not affected by light, heat, degree of saltness of the water, food, oxygen, carbon dioxide, foulness of water, water pressure due to the varying depth at which the fish may be, water currents or sound. Parker's method was to cut the nerves to the lateral lines in a number of individuals and to compare the behavior of these individuals with that of normal fish when the two were subjected to the various stimuli listed above. In the operated fish the lateral line organs were not in use while in the normal fish they were functioning in the usual way. If the two sets of fish behaved in the same way when subjected to these various stimuli it was concluded that the stimuli did not affect the lateral line organs. If the normal fish were affected by certain stimuli to which the operated fish did not respond it was concluded that this failure to respond was due to the fact that the lateral line organs were not functioning in the operated fish. In the case of current for example it was found that all normal and operated killifish tested swam against the current and that it was impossible to detect any difference in their behavior toward it. The conclusion was that current did not affect the lateral line organs. By this method Parker found but one stimulus that affected the lateral line organs of the killifish. When normal killifish were placed in an aquarium they came, after a little time, to swim near the surface. If then the table on which the aquarium rested was gently rocked by a person invisible to the fish, they darted at once to the bottom. Fish in which the lateral line nerves had been cut did not show this behavior, but remained near the surface of the water. The operated fish were in no way affected by the movement imparted to the water unless they came so near the top of the aquarium as to feel the ripples on the surface of the water. They then descended a little until

they were in water not disturbed by the ripples. They doubtless became aware of the ripples through their action on the nerve endings in the skin. It was found that the rocking of the aquarium produced vibrations, i.e., back and forth movements of the water—at the rate of about six per second. It is these vibrations, too slow to affect the ear, to which the lateral line organs are sensitive. The movements of the water doubtless reach the lateral line organs through the pores in the skin.

Parker found that normal killifish descended to the bottom of the aquarium when strong ripples were produced by blowing on the surface of the water. Fish with cut lateral-line nerves did not go to the bottom when ripples were produced. They merely kept out of the agitated water very near the surface. He adds: "There is no doubt in my mind that when wind blows on the surface of the water it causes a motion of the deeper water which stimulates the lateral line organs." In this way fish are made aware of wave action before they reach the agitated surface and may avoid it by descending.

When a stone was dropped into an aquarium containing normal killifish in such a way that they could not see it, the fish responded by springing away from the center of disturbance. Fish with cut lateral-line nerves did not respond. Parker concludes that "disturbances produced by such an object as a stone falling into the water stimulate the lateral-line organs with more or less directive effect." The disturbances produced by jumping frogs or leaping fish may thus be detected and located at night. The caster's bait or possibly even the gently-falling fly may be located by their impact on the water, when it is not possible for the fish to see them. The fish then possesses a capacity not present in land animals and obviously of great use to it.

Parker (1910b), has also studied the lateral line organs of the salt water dogfish (*Mustelus*). In this form he found that *pressure* on the lateral line caused the breathing to be slowed or stopped, even when the skin itself had been made insensitive to pressure as well as

to slow vibrations. The same slowing or stoppage of breathing took place when a stream of water was played on the lateral line.

Meantime Hofer (1908), had investigated the lateral-line organs of five species of European fresh-water fish. He did not find them sensitive to vibrations, i.e., back and forth movements of the water, however slow, so that, in this particular he does not agree with Parker. He found the lateral line organs in these fish sensitive only to continuous pressure of the water in one direction, that is to currents. They enable the fish to detect currents and to regulate the position of its body and its movements with reference to them. This view has been confirmed by Steinmann (1914), who found that the fish upon which he worked tended to turn so as to head against a stream of water played against the lateral line. Hofer believes that fish detect by the lateral line organs the presence of unseen solid bodies such as stones, and thus avoid colliding with them. As a fish swims forward its body ordinarily thrusts aside the water. As it approaches a solid there is resistance to the displacement of the water so that a back-pressure is produced which affects the lateral-line organs. In this way a moving fish is made aware of its approach to a solid body and is able to avoid it even in darkness.

### 2. *The Sense of Hearing in Fishes.*

Vibrations more rapid than fifteen per second affect our ears and are perceived as sounds. Our ears consist of three principal parts, the external ear, the middle ear and the internal ear. The structures of the external and middle ears are not sensitive to sound, but serve merely to collect the sound waves and conduct them to the internal ear, which alone is sensitive to them.

In fishes no trace of any part of an ear is usually visible on the outer surface of the head and this gives rise to the impression that fishes lack the ear and are therefore deaf. But although the external and middle ears

are lacking in all fishes dissection shows that an internal ear is always present deeply imbedded in the bone or cartilage of the skull. In some sharks and skates a slender tube leads from the internal ear to the top of the head and its outer end is visible there. With this exception the internal ear of fishes does not reach the surface.

If fish hear, the sound waves must get to the internal ear by traversing the solid bone or cartilage. Since water is a medium 775 times as dense as air, vibrations in it possess many times the energy of similar vibrations in air—and may therefore easily traverse the tissues of the head and reach the internal ear. At the old swimming hole it is a favorite pastime of boys to crack together stones under water after another boy has dived. The painful effect on the submerged human ear of the sounds thus produced is evidence enough of the greater energy of vibrations in water compared with those in air.

But although fish have the essential organ of hearing much like our own, and although sound waves may reach this organ through the solid tissues of the head, it by no means follows that fish hear. Earlier observers (e.g. Hunter, 1782), thought that fish *must* hear because they have internal ears. Later Kreidl (1895), removed the internal ears of gold-fishes and, finding that they were sensitive to certain sounds, concluded that these sounds were *felt* or perceived by the skin, as we may feel certain sound waves when the hand is held in water through which they are passing. He believed that the ears of fishes were *not organs of hearing.* At the monastery of Krems in Austria it had long been the custom to approach a certain pond and ring a bell. At the ringing of the bell trout assembled to be fed. This was taken as evidence that the fish heard the bell. Kreidl investigated this report, but found that the fish assembled when the pond was approached even though the bell was not rung. He concluded that they came at the *sight* of the bell ringer not at the *sound* of the bell. It appeared then that fish in water did not sense the sounds of a bell in air.

Kreidl concluded that they did not use the ears for hearing.

Later an American, Parker (1903, 1903a, 1910a, 1910b, 1911a, 1912a), held that this view was wrong. He found, as had Kreidl, that fish responded to sound. He used the killifish (*Fundulatus heteroclitus*), and squeteague (*Cynoscion regalis*). The killifish were placed in a cage suspended in an aquarium. One end of the aquarium was a sounding board to which was attached a bass-viol string string the vibrations of which were transmitted through the water. In other experiments he placed a vibrating tuning fork against the sounding board. When normal fish were tested in this apparatus they responded to the sound by breathing more rapidly, by movements of the pectoral or tail fins or by springing. Fishes in which the nerves of the ear had been cut rarely gave these responses. They sometimes responded when the bass-viol string was used, but this was probably because it gave rise not only to sound waves, but also to slower vibrations which affected the lateral-line organs of some of the fish. Fish with cut ear nerves gave no response to the sound waves from the tuning fork, for it produced no disturbances in the water except sound waves.

Fishes in which the ears were intact, but in which all the nerves to the skin and lateral line had ben cut, responded to the sounds in the only way possible for them, by increased rate of breathing. Such responses as they gave were hardly to be distinguished from those of normal fish. It was clear then that the killifish could hear so long as the nerves to the ear were intact even when all the nerves supplying the skin and lateral line had been cut. The only possible conclusion is that fishes use the internal ears, but not the skin or lateral-line, as organs of hearing. How then explain the fact that the goldfish from which Kreidl had removed the internal ears, were still able to hear? Kreidl performed this operation by making a small opening in the top of the head and pulling out the internal ear with a pair of forceps. It remained for Bigelow (1904), a pupil of Parker, to show

how Kreidl had fallen into error. Bigelow repeated Kreidl's experiments. He found, however, that when he pulled out the internal ear through an opening in the top of the head, he did not get it all. The part of the internal ear concerned in hearing remained in the head and the fish could still hear. The part removed in this operation is not concerned in hearing, but is an organ of equilibrium by which the fish keeps its balance. Its removal does not affect hearing. When Bigelow cut the nerve to the internal ear the goldfish were rendered quite deaf. Thus at last it was shown not only that fish hear but hear with the ears. As in other animals the internal ears are at the same time organs of equilibrium.

Haempel (1911), has more recently reinvestigated the question, and has used for the purpose European minnows and trout and an American fish, the common bullhead (*Ameiurus nebulosus*). He arranged an electric bell suspended in an air-filled metal tube which was immersed in the water of the aquarium. He also employed a loud whistling sound made by blowing through the fingers. Both sounds were thus produced in air from which they penetrated into the water of the aquarium, but presumably with greatly reduced intensity. Normal young bullheads responded to both sounds. A young bullhead from which the internal ear had been removed gave no response to either sound. Haempel concludes that the young bullhead hears sounds produced in air. On the other hand he was unable to get evidence that the minnows and trout with which he worked are able to hear. He considers them quite deaf. It is possible that the fish that Haempel found unable to hear sounds produced in air would respond to those produced directly in water. In that case his results would agree with those of Parker and Bigelow. A difference in the sensitiveness of fish of different kinds to sound is to be expected. The bullhead may be so sensitive that when in water it is able, as Haempel's evidence indicates, to hear sounds made in air. Other fish such as the minnows and trout used by Haempel may be able to hear only the more in-

tense sounds produced directly in water. Because they do not appear to hear sounds produced in air does not justify us in concluding with Haempel that they are deaf.

The sounds audible to fishes are then probably not usually those produced in air—for ordinary sound waves travelling through air have too little effect on the much denser water. But the evidence indicates that sound waves set up in water or those reaching water from some solid like a boat are sensed by fishes. Hence the fisherman may talk in a boat without appreciably disturbing the fish, but he may not produce sounds by striking the boat itself. No doubt the sound of his own voice travels through his body and through the boat to the water, but it then has probably too little intensity to be effective. Since we have little experimental knowledge as to how any of the game fishes react to sounds produced in water, it is as well for the sport fishermen to be as silent as he can.

It is quite possible that certain fishes may be attracted by sounds. This is indicated by the facts that some of them produce sounds. The male squeteague (*Cynoscion regalis*) has the ability to make sounds, but the female has not. It is not impossible that these sounds attract the female. Haempel (1911), relates that in parts of Europe fishermen are wont to attract catfish by means of sounds. In one case a wooden instrument is used, in another the hook is baited with a live frog and the water then struck with an instrument which produces a sound like the croaking of a frog.

3. *The Visual World and the Sense of Sight in Fishes.* The appearance of its visual world to the fish is determined in part by the medium through which it looks and in part by the peculiarities of its eyes.

A. THE VISUAL WORLD. The human eye is not adapted for clear vision when immersed in water, but it is possible to use an instrument like an inverted periscope (Reighard, 1908), and by means of it to see objects under water while the head remains in air. When such an instrument is used the clearest ocean water looks

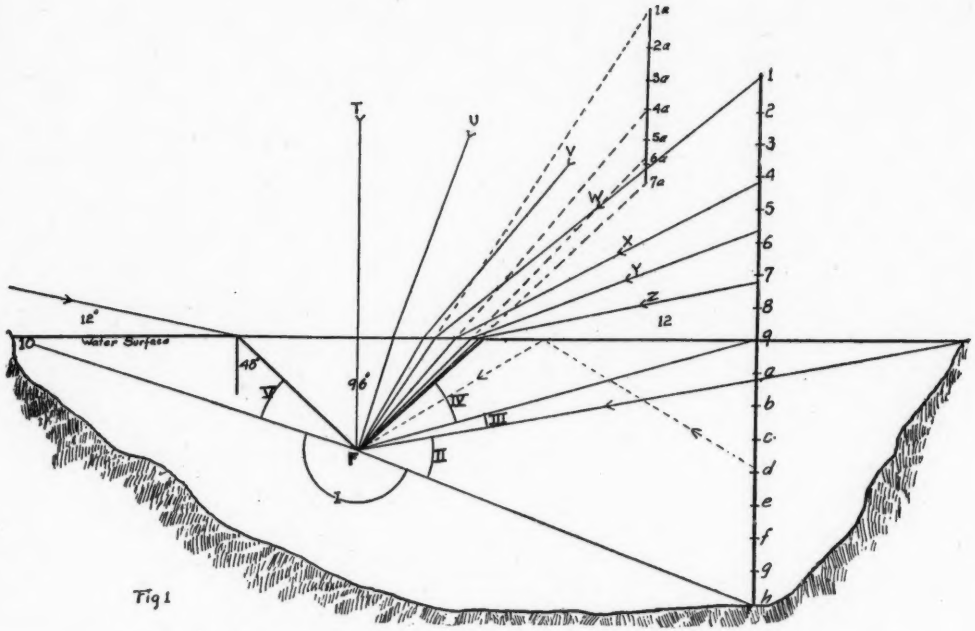


**Figure 1.** Diagram of a cross section of a pond to show how light reaches the eye of a fish. For explanation see text. Modified from Vigueron, 1913.

hazy. Objects at a distance of fifteen or twenty feet appear as though seen through a thin fog, while objects at a greater distance are less distinct and finally invisible. Into a bluish opalescent haze retreating fish vanish and from it emerge those that approach. The opalesence is due to numerous small floating organisms and inorganic particles which interfere with the light and reflect it back and forth. As a result of these reflections and of those which take place from the bottom and from the lower face of the water's surface the under-water light is more diffused than that in air. It penetrates into crannies and beneath objects with the result that shadows are much less in evidence than in air and all objects therefore appear less in relief. They have somewhat the flatness of those in shadow pictures. These objects may appear distorted when seen through layers of different density owing to differences of temperature. They doubtless lack somewhat of the color they have in air for the reason that water tends to obstruct the passage of red light-rays. Red objects at some depth must therefore appear less red than at the surface and objects of other colors are somewhat altered in appearance.

But the water affects the visual world of the fish in another respect more important than any of those enumerated. While we see no sharp upper limit to our atmosphere, the fish has always above him the sharply defined surface of the water. Through this he sees the outer world and in it he sees reflected a large part of the under-water world. Figure I shows a cross section through a pond and from it may be learned what a fish would see with its eye located at F. On the right is represented a graduated rod the divisions of which are lettered below water and numbered in air. From F, the fish sees, in the angle I, the bottom of the pond between H on the right and point numbered 10 at the left. In the angle II he sees the rest of the bottom and the submerged part of the staff below A. In the angle III, the fish sees a part of the water surface and the submerged part of the rod between 9 and A. All these things are seen directly and,

except as indicated above, appear as they would in air. In the angles IV and V the fish sees the rest of the water's surface, except that lying within the angle marked 96°. The lower face of the water's surface in the angles III, IV, V, is a reflecting surface—like that of a mirror. A ray of light from the point near D on the staff is indicated by the dotted line and its direction is shown by the arrow heads. When such a ray strikes the lower face of the water's surface at any angle greater than 48° with the vertical it does not emerge into air, but is reflected back into the water. Thus the ray from D is reflected and reaches the fish's eye at F and the fish sees an image of D in the surface of the water as in a mirror. In whatever direction the fish looks within the angles III, IV and V, it does not see out into the air, but sees rather this mirror like opaque surface of the water with the inverted images of submerged objects visible in it. In the angle IV the fish therefore sees an inverted image of the submerged part of the rod. Whatever the fish sees in the water within the angles III, IV, V it may also see duplicated by an inverted reflected image. These images are like those we see when we look from air at the surface of still water, especially in the morning or evening.

Since light penetrates into the water from air the fish is able to see objects above the surface. When a ray of light penetrates still water obliquely it is bent or refracted toward a perpendicular extending downward from the water's surface. As shown in figure 1, vertical ray T is not refracted and passes directly to the eye of the fish at F. The rays U, V, W, X, Y and Z are refracted in varying degrees depending on the obliquity with which they strike the water. Even a ray which comes from a point near 9, just above the surface of the water, and is therefore nearly parallel to that surface, penetrates. It is refracted at an angle of 48°. As appears from the figure light reaches the eye of the fish from all visible objects above the surface—that is from all objects between the horizon on all sides and the zenith. But the

light *seems* to come from the direction in which it is travelling when it reaches the fish's eye. Therefore the point below 7 on the emergent part of the rod appears to be near 7a, and the points above it at 1 and 4 seem to be at 1a and 4a as shown in the figure. It results that so much of the rod as is visible above water appears to be higher up than it really is. As shown in the figure each of the visible subdivisions of the rod appears shortened and the lower ones are more shortened than the upper, as may be seen by comparing the division below 6 to that below 6a. Only objects near T are seen in their natural proportions.

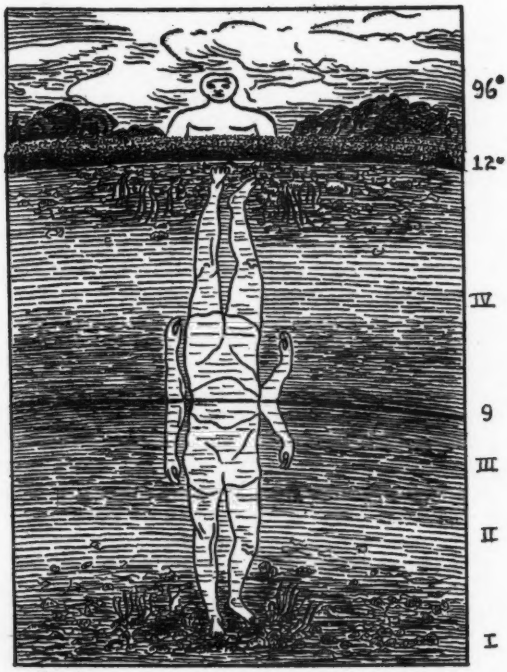


Figure 2. View of objects above and below water as they appear to a fish. Explanation in text. Modified from Vigueron, 1913.

Figure 2 shows one view that a fish might get. For comparison the various angles at the right of figure one are indented on the margin of figure 2. In the angles I, II, III the fish sees directly the bottom and the submerged part of the bather. In the angle IV he sees the inverted image of the submerged part and of the bottom. Within the angle marked 96° in figure 1, the fish views the outer world. It is as though he looked through a round window over his head—or as though he looked out through a funnel with an angle of 96°. On all sides of this window the lower face of the water's surface is opaque to the fish, and he sees in it only the reflected images of submerged objects. Through the window he sees the outer world. In this view of the outer world two things are noteworthy. First, the tops of the trees and the upper part of the bather are shortened or depressed as are the segments of the rod 1a to 6a, in figure 1. Second the part of the bather just above the water and the trunks of the trees are not visible at all and in their place is seen a dark band. The reason for this should appear from a study of figure 1 within the angle 12°. In figure 1 rays from points on the rod below 7 are represented as penerating the water and the fish should see these points. But the amount of light that penetrates the water from any points on the rod depends on the angle at which that light strikes the water. Since the rays from point 8 strike the water at a very acute angle most of them are reflected and but few penetrate. More rays penetrate from points higher up and fewer are reflected. Hence the visibility of exterior objects to the fish depends on their apparent height above the surface. Objects in the direction of the line Z and below it within the angle 12° are practically invisible. If these objects are near the fish they may be quite close to the surface of the water, if on the shore they may be higher, if more distant they may be very high and still all are invisible to the fish. If a mirror is placed in the water at the point F in figure 1 and tilted at the proper angle the outer world is visible to one looking down into the mirror (Von Aufsess, 1913),

but men at a little distance on shore, the lower parts of buildings and the trunks of trees are not visible. Wood (1906), has used a specially constructed pin-hole camera to make photographs which show how the outer world appears to a fish in a pond. With this apparatus he has photographed a circle of nine men as they would appear standing about a small pond with buildings and trees in the background. Although the men are very close to the camera very little of them is visible below the knee and the lower stories of the buildings do not appear in the picture. With a similar apparatus Wood has photographed a straight row of nine men as they appear to a fish in an aquarium when the center man is standing about eighteen inches from the glass side of the aquarium. The end men in the row are just included in this picture, so that additional men at either end of the row would be invisible. From the photograph we may estimate that the row of men is about 15 ft. long. A line from the outside of the end man 7½ feet distant, to the center of the side of the aquarium then makes an angle of about 12° with the aquarium glass. Within this angle which corresponds to the line 2 in figure 1, nothing is visible in the photograph. If a six-foot man stands at the edge of a pond with his feet at the water level a line drawn from the top of his head so as to make an angle of 12° with the water surface strikes that surface at a distance of about twenty-five feet. From this very rough calculation it is probable that a six-foot man would be invisible to a fish at a distance of twenty-five feet. As the man comes nearer his head and shoulders become gradually visible and then the rest of his body, but all distorted as already described. From this same calculation it seems that the sun's rays would not penetrate the water appreciably until they formed an angle of 12° with its surface. Hence sunrise comes later for the fish than for us, and sunset earlier and his mid-day is much shortened.

Von Aufsess found in his experiments with the mirror that all subjects above water were seen surrounded by a

rainbow like fringe so that in this respect that part of the fishes visual world differs from ours. The writer has recently verified Von Aufsess' observations with the mirror and has obtained views essentially like those shown in figures 2 and 3. Objects within the angle 12° are visible at its upper limit, but become gradually less visible as they are lowered, and disappear completely at about the middle of this angle. All objects are fringed with color, more red near the horizon, more blue higher up. Objects within the angles IV and 96° are clearly seen when the water is quite still, but are distorted and confused upon the slightest movement of its surface.

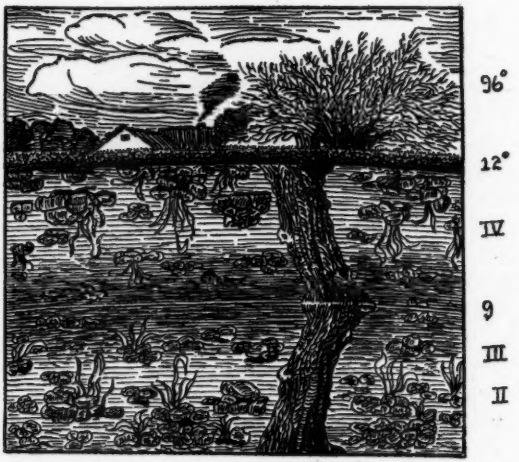


Fig. 3

Figure 3 shows a view above and below water as it appears to a fish, with the angles of figure I indicated on the margin. In the views shown in figures 2 and 3 the fish would see all the branches and twigs of the trees as well as all other objects bordered with a rainbow fringe.

Imagine then our dawn and twilight to be greatly lengthened and our mid-day shortened. Imagine the

light weak and the air filled with a thick fog which obscures objects at a little distance. Imagine shadows to be much reduced in intensity, as they are on a foggy day, and all objects correspondingly flat in appearance. Imagine a little way above your head a great mirror extending parallel to the earth. Through a round, overhead hole in this you see in unnatural positions, distorted and rainbow-fringed, the upper parts of trees and other objects that lie above it. Their lower parts are invisible to you. Imagine that elsewhere, as you look upward, you see only the reflecting lower surface of the mirror and in this, upside down, you see the images of all objects that lie beneath it. You will then have realized something of the difference between the fish's visual world and our own.

B. STEREOSCOPIC VISION AND ACCOMMODATION IN FISHES. But not only is the visual world of the fish different from our own, the eyes through which it is viewed are unlike ours. They are usually without lids so that the fish has always a glassy stare and never closes the eyes in sleep. They are without tear glands or tear ducts for with its eyes always bathed in water the fish has no need to weep. These differences do not affect vision, but there are other differences that do. Our own eyes look forward and cover a relatively limited field of view in which the two eyes see the same objects within the field of distinct vision. Each eye gets a slightly different view of any solid object and by the combination of these two views we get what is called *stereoscopic* vision. Objects appear to us more in relief than they would if viewed by a single eye. In the fish the eyes look outward, so that their fields of view overlap but little. The fish therefore has a field of view much wider than ours. To look about he does not need to turn the body or the eyes to the same extent that we must turn our eyes or heads. But since he views each object (except those included within an angle of 5° in front of his head), with one eye only—these objects probably lack relief (except within the 5° angle). The fish has then very limited stereoscopic vision, if indeed he has any (Tschermak,

1914). But since the lighting of his world gives objects the appearance of flatness the fish has perhaps less use for stereoscopic vision than have we.

When the normal human eye is at rest it sees clearly only objects at a distance of more than twenty feet. To see nearer objects clearly the eye must be focussed. Focussing may be accomplished in optical apparatus in two ways. In a camera we focus by moving the front or back of the camera so as to alter the distance between lens and ground-glass. For remote objects this distance must be short; for nearer effects it must be increased. But if the lenses in our cameras were flexible we might keep them in focus by altering the *shape* of the lens to accommodate objects at different distances. For distant objects the lens would have to be made flatter, for near objects more spherical. In practice we cannot alter the shape of a glass lens, but we focus by substituting a lens of different curvature. It is by changing the shape of the lens that focussing is accomplished in the eye of man and other higher land animals. When the eye is at rest the lens is flattened and thus adjusted for distant objects. For nearer objects, through muscular action, the lens becomes more spherical. An unconscious muscular effort is therefore needed to see near objects clearly. To the land animal distant objects are clearly visible. Their rapid approach through the thin atmosphere often means danger of food. It is therefore essential that the resting eye of the land animal should be fitted to see them. At the same time it needs to be instantaneously adjustable for near objects.

In the fish the spherical lens of the eye does not change shape. When the eye is at rest it sees clearly only objects at a distance of about three inches to a foot (Beer, 1894). The fish then sees like a rather short-sighted person; everything at a distance is blurred. To see distant objects it contracts a muscle which pulls the lens nearer to the retina. The action is like the focussing of a photographic camera by moving the lens. It may focus objects 30-40 ft. distant. So the fish with resting

eye sees clearly the near objects not obscured by the haze in the water. When need comes it adjusts the eye to the more distant and less visible objects, fleeing prey or approaching enemy. It does not need to be always alert to objects at a distance in the water for these move through the dense medium with relative slowness, and they are more or less obscured by the opacity of the water. It is probable that the degree of contraction of the muscle which moves the lens aids the fish to appreciate the distance of objects from it.

C. COLOR VISION IN FISHES. The experience of anglers with artificial flies indicates strongly that fish discriminate between colors. On the other hand there are scientific investigators who hold that fish do not see colors at all—but are totally color blind (e.g. Hess, 1911).

To the totally color-blind person there are no green trees or red flowers. He sees the world in blacks and whites and grays. So we see objects in an uncolored photograph and tell them apart by size and form and by their varying shades of the one color. To the totally color-blind the world appears much as in such a photograph. He tells objects apart, not by color, but by form, size or shade. If he is shown little skeins of colored yarn all of the same size and shape and is asked to put together those of the same color, he matches blues and reds and greens. They all look gray to him, and he puts together those skeins that to his eye have the same shade of gray.

When a fish looks at an artificial fly, he sees, according to one view, no color at all. The fly seems to him to be made up of white, black and grey parts. According to this view he tells the flies apart only by their size and shape and by the size, shape and shade of the different grey, black or white patches that make up their patterns. If this view is correct the gaudy colors of our flies and other lures are useless so far as their effect on fish is concerned. They catch our eyes only.

Whether this view, that fish are color-blind, is correct is then a matter of some interest to makers and users of

lures. How may we test it? A human being may tell us whether two objects of like size and shape, but of different colors look alike to him. If he can learn to tell them apart we know that he is not color-blind. The problem with the fish is then to find some way of *making it* tell us whether two objects identical except for color, look alike to it. After several years work, Miss Cora D. Reeves (1917), a student in my laboratory has succeeded in doing this.

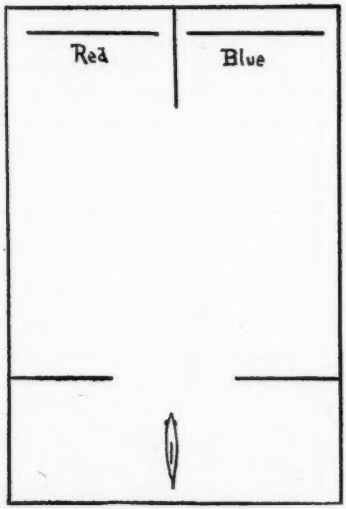


Figure 4. Ground plan of aquarium for testing color vision in fish.

The fish (common sunfish and horned dace) is placed in an aquarium (Fig. 4), divided into two compartments by an opaque partition. The fish is placed in the smaller compartment which communicates with the larger by a door. At the far end of the larger compartment are two plates of opal ground glass illuminated, the one with blue the other with red light. The door is now opened and the fish sees in the larger compartment the blue and red plates. He has previously been trained to come to a blue plate to be fed. If now the fish goes to the blue plate he

is fed; if he goes to the red plate he is not fed. The fish, after one trial, is returned to the smaller compartment and again the door is opened and he makes a choice of the blue or red plate and is rewarded by food if he selects the blue plate. After many trials the fish *learns* to go at once to the blue plate to be fed. He rarely makes a mistake and there can be no doubt that he has learned to distinguish the blue plate from the red. If the blue plate were always in the same position, always at the left of the red, the fish might learn to tell them apart by position. He might learn no more than to turn to the left in order to get food. It is therefore necessary to shift the plates in an irregular way as the experiments progress, so that the blue is sometimes on the fish's right and sometimes on his left. The plates are of the same form and size and, with shifting, are not to be told apart by their relative positions. It would seem natural to conclude that the fish had therefore distinguished them by their colors. At first sight the evidence seems sufficient to show that fish can discriminate the *color* blue from the *color* red. But this is an error and one into which earlier investigators were sometimes led.

Let us suppose now that the fish is actually color blind. In that case both the blue and the red plates appear to him to be gray. But one of these (to him), gray plates may be lighter than the other. If we should photograph the red and blue plates they would both appear grey in the printed picture, but one might be darker than the other and it would be very easy to distinguish them in the photograph. So the fish may discriminate between the colored plates because they appear to him to differ in *brightness* although to his eye they may not differ in color. If now we make the red plate of the same brightness as the blue and the fish can still tell them apart, we may be sure that he does this by the color alone, for the plates will then be identical in size, shape and brightness and will differ in color only. It is not easy for us to match two colors by the eye or by any of our instruments so that they will be of equal brightness for the fish, but

we may make the fish do this for us. After the fish has learned to distinguish the blue plate from the red, we feed him several hundred times before these two plates. But after he has been fed ten times, we change the brightness of the red plate. The fish still discriminates the two plates. Again we change the brightness of the red plate after ten feedings. Thus we continue changing the red plate from time to time until we have tried red of every brightness from very dull to very brilliant. Amongst all the brightnesses of red that we have thus tried there must be one that nearly or quite matches the brightness of the blue. When this condition of matched brightness for the two plates is reached the two colors should appear to a color blind fish to be of the same shade of gray. If the two plates appear to the fish as indistinguishable grays he could not tell them apart and he would then be unable to go regularly to the blue plate for food. He would go as often to the red as to the blue and would remain half the time unfed. If the fish then were color-blind a point would be reached in our two hundred experiments at which he would make mistakes about half the time, and so fail to get food half the time. If he were *not* color-blind he would continue to distinguish the blue from the red, no matter what the brightness of the red, would make few or no mistakes and would get food nearly every time.

The fish in the experiments that I am describing learned, after long training, to discriminate the blue and red plates at all brightnesses of the red. Thus with plates of the same size and shape and brightness and with the possibility of distinguishing them by position eliminated, we can conclude only that the fish discriminate between the plates by their colors alone.

Other methods than that of training with food have been used in the study of color vision in fish. When they are shown two lights of different colors and of presumably the same brightness they often show difference in behavior toward them. They are apt to be repelled by red, but not by blue, and to approach a red plate in a

different way, and far less frequently than a blue or white. This indicates that the plates differ for them in color. Flounders when placed on back grounds of different colors (Mast, 1916), become after a time of the same color as the background. Blinded flounders do not undergo this color change, and hence it is concluded that color differences are appreciated through the eyes. Mast has illustrated these color changes by some very striking color-photographs.

And so in spite of the strong scientific opinion to the contrary, our age-long belief in the value of color in our artificial flies is shown to be warranted. But the warrant extends to blue and red only; we may say that we know that fish discriminate these. It is probable that they discriminate other colors as well.

## III. LEARNING.

Some instances of learning by fish have been already referred to. The catfish quickly learns to tell a bit of cotton wool soaked in meat juice, from one not so soaked. The sunfish and dace learn to come for food to a patch of blue light. The trout learns to come toward the man who feeds him. To cite in detail all other known instances of learning would take too long. A few will suffice.

Some years ago I carried on experiments on the gray snapper of the Gulf of Mexico (Reighard, 1908). There was a school of about 75 of these fish under a dock at the Dry Tortugas. For a time I fed them by throwing to them small fish known as hard-heads. These were greedily eaten. The little fish were eaten even when they were stained bright blue or red. They were eaten when soaked in various noxious chemicals. Finally I cut some tentacles of jelly fish into small bits and placed these bits in the mouths of the red stained hard-heads that were being given to the grey-snappers. These tentacles, which were so placed that they projected from the mouths of the hard-heads, are covered with stinging nettle cells.

When the red hard-heads thus equipped with stinging tentacles were thrown to the snappers they at first ate them. But a single experience was enough to teach the average gray-snapper that the tentacled hard-heads were not good to eat. After taking one he did not care for more. Not only did the grey snappers stop eating these red fish—but during the rest of my stay on the islands they would not touch them. Nearly three weeks after their first experience they still refused red hard-heads even when they were not equipped with tentacles. At the same time they ate hard-heads of other colors. Thus the snapper not only learned to let red hard-heads alone, but they learned also to tell them from those of other colors. That fish in general *may* learn to avoid a lure or baited hook seems clear. Whether they do avoid it depends in any particular case on how hungry they are, for a hungry fish, like a starving man, will eat almost anything.

Many years ago Moebius (1873), placed a pike in an aquarium which was divided by a partition of glass. On the opposite side of the partition from the pike he placed some minnows. The pike made frantic efforts to get the minnows, but at each attempt, bumped his snout against the glass. After a time, profiting by experience, he ceased to try. The partition was then removed so that the pike had free access to the minnows. But he had learned his lesson, and did not try to get them. Thus a happy family was created; the lamb and the lion lay down together. But finally the pike, perhaps because he grew hungry or because he happened to bump against one of the minnows, made another attempt and succeeded. The minnows then disappeared very quickly, for the pike had learned once more. The experiments of Moebius were repeated by Triplett (1901), who used perch instead of pike and obtained results like those of Moebius.

More recently Thorndike (1911), and Goldsmith (1914), have shown that fish may learn to come to a particular point in an aquarium to be fed and that they re-

member what they have learned for as long as eighteen days. Fish may also learn and remember in what direction to go to pass through an opening in a partition in order to reach the nest (Goldsmith, 1914). They may also learn and remember the shortest way through partitions with openings at different places. Churchill (1916), placed two such partitions across an aquarium so that it was divided into three compartments. Food was placed in the compartment at one end and gold fish in the compartment at the opposite end. The gold fish at the first attempt sometimes required nearly two hours to get through the openings in the two partitions and the intervening compartment and reach the food. But as they repeated the attempt to get through they succeeded in shorter time until finally they learned to go from end to end of the aquarium in three or four minutes.

## IV. SUMMARY.

We see then that fish possess all the senses that men have and one besides. The sense of touch they have of course. The sense of smell, as in man, makes them aware of some things good or bad in their neighborhood. If bad they flee from it. If good they seek it and are directed in the search by the sense of smell. When they come into contact with the food, they may taste it with the organs on the surface of the body. Then with the help of touch they locate and seize it.

Mass movements of the water—slow vibrations and currents, they sense by means of their lateral-line organs —structures not possessed by land vertebrates. Thus probably they are aided in detecting approaching danger or possibly in securing food. These same organs may help them to detect currents in the water and to regulate their movements with reference to them. They may also aid the fish to detect unseen solid bodies before they swim against them.

More rapid vibrations of the water they sense with their ears, as sounds. Owing to the great energy of

sound waves in water, these pass through the hard tissues of the head and reach the internal ear unimpaired. Thus no other parts of the ear are necessary.

Fishes see much as we do—but their field of vision is larger. Owing to the diffuse and weak light of their world and to the position of their eyes, objects appear in less relief to them than to us. Objects in still water are seen by most fishes not only directly, but also upside-down, mirrored in the lower face of the water's surface. Objects in air and above the water about the shore of a pond are also visible to them. But these objects are seen in unnatural positions distorted and fringed with color and their higher parts only are visible. Like a short-sighted person, the fish sees near objects distinctly, distant objects less clearly. Only by a muscular effort does he see distant objects clearly, in so far as they are visible through the opalescent water. Fishes distinguish colors, but whether they see as many colors as we do is not known. Nor can we say that the colors appear to them in the same way that they do to us.

And so the faith of the fisherman in his gaudy lures is justified. His belief that fish may learn to avoid them or to keep out of nets appears to be founded in fact.

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# PROCEEDINGS OF THE FORTY-SIXTH ANNUAL MEETING

The Forty-sixth Annual Meeting of the American Fisheries Society was held at New Orleans, La., on October 16 to 19, 1916, the President of the Society, Professor Jacob Reighard, presiding at all the sessions.

## *Monday, October* 16.

### OPENING SESSION.

The Hon. Martin Behrman, Mayor of the City of New Orleans, was introduced and presented an address welcoming the Society to New Orleans.

Hon. M. L. Alexander, President of the Louisiana State Department of Conservation, also presented an address of welcome on behalf of the Governor of Louisiana.

President Reighard responded to the addresses, after which the session was adjourned.

## *Monday Afternoon Session, October* 16.

In the absence of the Recording Secretary and the Treasurer, Mr. Carlos Avery of St. Paul, Minn., was elected Acting Secretary and Mr. John P. Woods of St. Louis, Mo., Acting Treasurer, to serve during the meeting.

Fifty-eight applications for membership were presented and upon vote of the Society the applicants were declared elected. The names of these new members, together with three others elected later during the meeting, will appear in the membership list to be issued in the September number of the Transactions.

### REPORT OF THE RECORDING SECRETARY.

(Read by the Acting Secretary.)

*To the Members of the American Fisheries Society:*

The work of the Recording Secretary for the past year has been directed chiefly toward the preparation and

publication of the Transactions. This task for the past year has involved more than the usual amount of responsibility and labor, since the very limited program presented at the San Francisco meeting provided, aside from the Proceedings, only enough material for the December number. The remainder of the papers published during the year have been furnished by members at the personal request of the editor, and this involved no little correspondence as well as anxiety. However, I believe the quality of the TRANSACTIONS has in no way suffered. The four numbers, the last of which is just now off the press, comprise about 240 pages.

One of the most important occurrences of the year, or in fact of recent years, was the addition to our membership of fifty new Patrons, following the San Francisco meeting,—chiefly through the agency of Capt. Jefferson F. Moser of San Francisco.

The number of active members has been increased during the year by about twenty. The names of these members appear in the revised membership list just issued in the September number of TRANSACTIONS. According to the by-law passed at the last meeting these were elected by the committee formed for that purpose. In other words they became members at once, receiving the TRANSACTIONS for the year and being listed as of the year 1915-16.

The sale of publications has been very slight during the year, amounting to only twelve numbers of the quarterly, for which six dollars was realized.

There is on hand a large number of the issues of former years, especially from 1904 to the present time. This fact forms the basis for a recommendation to the Society to be presented later. The Secretary's file, to be kept permanently in the hands of the Secretary, is still lacking the 1903 volume, as well as those previous to 1893. Members encountering these volumes are urged to secure them for the Secretary's file, as it is evident that there should be as complete a file as possible of the Society's publications in the possession of the Society.

The Secretary-Editor believes that the time has arrived for the separation of these offices, as each of them involves a considerable amount of work, and they are not necessarily concerned with each other. A recommendation to the Society to this effect will be presented later.

Respectfully submitted,

RAYMOND C. OSBURN,
*Recording Secretary.*

New London, Conn., October 9, 1915.

This report was accepted and approved by vote of the Society.

*Recommendations to the American Fisheries Society*:

I. The back numbers of the TRANSACTIONS, especially since 1904, have accumulated in considerable numbers, and there has been but little sale of them at the present price, which is $1.50 for all except the 1910 volume which is $2.00.

In order to dispose of some of these and at the same time increase the income of the Society, I suggest that these be offered to members at half-price. Many of our members have been elected in recent years, and it may be that some of them will be glad to avail themselves of such a reduction in order to add to their series.

II. For the past forty-five years the Recording Secretary has also been Editor of the TRANSACTIONS. As the work of both of these offices has increased greatly, and as there is no necessity for their combination, it seems to the present incumbent that they should now be separated. Although the work of editing the TRANSACTIONS is vastly greater than the secretarial work, the present editor is willing to continue the editorial work without salary, thus permitting the honorarium of $50.00 a year to go to the Recording Secretary.

Respectfully submitted,

RAYMOND C. OSBURN,
*Recording Secretary.*

These recommendations of the Recording Secretary were referred to the Executive Committee.

Professor H. B. Ward, of Illinois, moved a vote of thanks to Capt. Jefferson F. Moser and Mr. Henry O'Malley for their work in securing the large number of Patrons, and also to the Patrons themselves for their interest in the work of the Society.

### REPORTS OF THE TREASURER.

(Read by Mr. Daniel B. Fearing.)

*To the American Fisheries Society*:

I herewith submit my annual report as Treasurer from October 1, 1915, to October 1, 1916:

#### RECEIPTS.

| | | | |
|---|---|---|---|
| 1915 | | | |
| | Sale of reports | $ 6.00 | |
| | Wm. Timson, Life membership fee | 25.00 | |
| | Yearly dues | 852.00 | $883.00 |

#### EXPENDITURES.

| | | |
|---|---|---|
| 1915 | | |
| Oct. 1 | Balance due Treasurer | $252.75 |
| Oct. 27 | R. L. Holmes, stenographer | 71.50 |
| Nov. 16 | C. J. Butler, P. M. Stamped envelopes | 21.36 |
| 1916 | | |
| Jan. 4 | Clark & Fritts, by Sec'y | 93.11 |
| Mar. 23 | " " " | 107.46 |
| Apr. 2 | " " " | 8.50 |
| May 18 | M. J. Sullivan, printing | 3.50 |
| Jan. 30 | J. H. Murphy, printing | 1.25 |
| May 26 | Clark & Fritts, by Sec'y printing | 129.43 |
| Aug. 18 | 800 reports and mailing by Sec'y | 192.25 |
| | Addressing and mailing 625 copies March | 6.50 |

| | | | |
|---|---|---|---|
| | 1,800 envelopes | 20.59 | |
| Aug. 31 | 400 reprints | 36.00 | |
| | 500 envelopes and printing | 10.68 | |
| Sept. 21 | Secretary's honorarium | 50.00 | |
| | Stamps by Sec'y | 6.00 | |
| | Notary's fee, Sec'y | .50 | |
| | 600 envelopes, Sec'y | 6.60 | |
| | Addressing 2 sets notices, Sec'y | 3.00 | |
| Oct. 1 | Interest on balance | 26.73 | |
| | Postage stamps | 2.00 | |
| | | $1,049.71 | |
| | Balance due Treasurer | | 166.71 |
| | | | $1,049.71 |

Respectfully submitted,
(Signed) C. W. WILLARD,
*Treasurer.*

Westerly, R. I., October 1, 1916.

*To the American Fisheries Society*:

I hereby submit my Annual Report as Trustee of the Permanent Fund of the Society, From October 1, 1915, to October 1, 1916:

Deposit Book Industrial Trust Co., Westerly, R. I., No. 8,540.

| | | |
|---|---|---|
| Balance as of report rendered October 1, 1915 | | $ 51.66 |
| 1915 | | |
| Oct. 9 | Deposit | 50.00 |
| Nov. 26 | Deposit | 2,275.00 |
| Dec. 24 | Deposit | 350.00 |
| Aug. 1, 1916 | Interest credit to this date | 72.90 |
| | | $2,799.56 |

Respectfully submitted,
(Signed) C. W. WILLARD,
*Treasurer.*

This deposit is in the name of "Permanent Fund, American Fisheries Society."

We certify that there was Twenty-seven hundred and ninety-nine dollars and fifty-six cents ($2,799.56), to the credit of the above account on October 9, 1916.

INDUSTRIAL TRUST COMPANY,
Westerly Branch.

(Signed) JAMES M. PENDLETON,
*Manager.*

The above reports were referred to the Auditing Committee by vote of the Society.

Mr. Daniel B. Fearing, of Rhode Island, as chairman of the special committee to further the amalgamation of the Pacific Fisheries Society with the American Fisheries Society, reported that the matter had been laid before the Pacific Fisheries Society and that it had been referred to the executive committee of that society. No further communication had been received.

## READING OF PAPERS.

### *The Use of Gasoline in the Treatment of Fin Trouble Among Brook Trout.*

BY H. L. RIPPLE, *Bayfield, Wis.*
(Read by Mr. W. E. Barber.)

Young brook trout in the Bayfield, Wisconsin, hatchery were attacked by fin trouble which killed off large numbers of them. Mr. Ripple tried the salt solution treatment without avail. Then he placed a number of them in pure gasoline for three minutes at which time they were apparently dead. On being placed in water, however, they all revived and recovered completely. Many more were subsequently treated, and while some were lost, the treatment proved, on the whole, very beneficial. Means for testing out the treatment in a scientific manner were lacking, and Mr. Ripple suggested that this be

done in order to make the method more accurate. (Abstracted.)

*Why Fridays for Fishes?* By Mr. John P. Woods, President of the Missouri State Fish Commission.

The custom of eating fish on Friday is connected with the abstinence from other meats on that day in the observance of certain religious tenets dating back to the dawn of Christianity. There is, however, no logic in permitting Friday to have a perpetual monopoly of this food.

When we recall that about three-fourths of the earth's surface is but a fish pasture, it is evident that fish festivals on other days will work no particular hardship on this aquatic tribe. The U. S. Bureau of Fisheries has prepared tables showing that the flesh of various fishes is as rich in food values as the various meats. Consumers generally should know this. A pound of salmon will produce as much tissue or body fuel as a similar amount of sirloin steak and at about half the price.

Cannot this Society inaugurate a successful "eat fish" campaign under the slogan "All days fry days for fishes"? (Abstracted.)

*The Construction of a Pond Cultural Station, and the Propagation and Distribution of Large-mouth Black Bass in South Carolina.* By. MR. G. W. N. BROWN, *Superintendent, U. S. Fisheries Station, Orangeburg, S. C.*

This paper appeared in the TRANSACTIONS for December, 1916, pp. 30-34.

*Conferva and Mejinko.* By MR. W. O. BUCK, *U. S. Bureau of Fisheries, Neosho, Mo.*

*Propagation of Small-mouth Black Bass.* By MR. O. P. CUSHMAN, *U. S. Bureau of Fisheries, Mammoth Spring, Ark.*

This paper appeared in the March, 1917, issue of the TRANSACTIONS, pp. 113-116.

Session adjourned.

*Tuesday Morning Session, October* 17.

REPORT OF EXECUTIVE COMMITTEE.

Mr. Henry O'Malley, chairman of the committee, reported upon the two recommendations made by the Recording Secretary, Prof. Raymond C. Osburn, and moved as follows:

1. That the offices of Recording Secretary and Editor be separated, that the $50.00 fee to the Recording Secretary be discontinued and that instead this officer be allowed his expenses at the annual meeting.

After some discussion by various members this was referred back to the committee for further consideration.

2. That the Secretary be authorized to sell the back volumes of the TRANSACTIONS to members only at half price, or at the rate of $1.00 for the 1910 volume and $.75 each for all other volumes.

This motion was seconded by Mr. Daniel B. Fearing and passed by vote of the Society.

READING OF PAPERS.

*Remarks on the Tile-fish*, by Dr. Hugh M. Smith, U. S. Commissioner of Fisheries, Washington, D. C.

Following the discovery of the tile-fish in 1879, Professor Baird, then U. S. Commissioner of Fisheries, was hoping to induce commercial fishermen to market it, when some violent catastrophe nearly exterminated the species. From 1892 to the present the tile-fish has been increasing in numbers, and in the fall of 1915 the Bureau of Fisheries undertook the task of introducing it on the market. It was necessary to hire a regular fishing schooner, guaranteeing fifteen hundred dollars for four weeks of fishing, but the sales of tile-fish more than covered the charter price. Since then the fishery has rapidly progressed and is being followed regularly at Boston, New York, Atlantic City and other ports of the New England and Middle Atlantic States. Apparently the fishery will yield 20,000,000 lbs. in the first year of its

existence, and up to this time the fishermen from New York say they have only been fishing on the outskirts of the grounds. The tile-fish is found only on the narrow edge of the coastal shelf, but there is undoubtedly an abundance of the fish on these very accessible grounds. (Abstracted.)

*An Unidentified Disease of the Black Bass in a Small Lake at Bernardsville, N. J.*, by Mr. Daniel B. Fearing, Newport, R. I.

The paper was discussed by Professor H. B. Ward, Dr. Geo. W. Field and Mr. W. O. Buck.

*Bass Raising in Texas*, by Mr. Mark Riley, San Marcos, Texas. (Printed in the March, 1917, TRANSACTIONS, pp. 107-112.)

During the discussion which followed, Mr. Riley brought out the fact that the young large-mouth black bass can be easily taken on dark nights by the use of a torch. As the schools of young bass do not separate till past the No. 1 fingerling stage, and as they rise to the light, they may be taken out with a dip net operated from a boat. This method Mr. Riley has found very successful.

*Federal Control of Fishing in Interstate Waters*, by Mr. Eben W. Cobb, State Superintendent of Fisheries of Minnesota.

Printed in the December, 1916, issue of the TRANSACTIONS, pp. 26-29.

The paper elicited considerable discussion over the difficulties of securing interstate cooperation by other means that by federal control. In only a few cases have the states concerned been able to reach an agreement.

The Society then adjourned to luncheon as the guests of the Department of Conservation of the State of Louisiana. At the close of the luncheon brief addresses were made by Mr. M. L. Alexander and Mr. Daniel B. Fearing.

*Tuesday Afternoon Session, October* 17, 1916.

The program of papers was proceeded with at once.

*Rules and Regulations of the Connecticut Board of Fisheries and Game, with Remarks Relative to Connecticut Game and Fish Industries*, by Mr. John M. Crampton, State Superintendent of Fisheries and Game of Connecticut.

Mr. Crampton's remarks were directed especially to the depletion of the shore and river fisheries owing to the lack of proper laws to regulate pollution, the seining of small fish and the placing pound nets in the mouths of streams. Discussion followed at some length by Messrs. John W. Titcomb, Henry B. Ward, Daniel B. Fearing, Geo. H. Graham, John P. Woods and W. O. Buck.

The session then adjourned for an automobile tour through certain parts of the city, terminating at the Southern Yacht Club.

*Tuesday Evening Session, October* 17, 1916, *at the Southern Yacht Club.*

Professor Henry B. Ward, of the University of Illinois, presented an address on the migration of the Pacific salmons, illustrated by numerous lantern slides.

Dr. Hugh M. Smith, United States Commissioner of Fisheries, spoke on "Some of the Features of the Work of the U. S. Fisheries," illustrating his remarks with lantern slides and motion pictures. One reel showed the work of the Bureau of Fisheries and of various western states in the propagation of the Pacific salmons; another covered the lobster propagation work of the Bureau of Fisheries on the Atlantic Coast; another represented extensive operations in the Fisheries of the Great Lakes, and the fourth reel showed the character of the important rescue work of the Bureau of Fisheries in reclaiming fishes stranded during the overflow periods of the Mississippi River and its tributaries.

Mr. M. L. Alexander, President of the Louisiana Department of Conservation, showed a motion picture reel on Louisiana bird life.

During the evening the glee club and orchestra of the Sophie Newcomb College for Women of Tulane Univer-

sity provided entertainment, and freshments were served. At the close of the session President Reighard called upon Professor Henry B. Ward to express the thanks of the Society for the entertainment provided.

*Wednesday Morning Session, October* 16, 1916.

By vote of the Society, the session proceeded at once with business, postponing the reading of papers.

REPORT OF THE AUDITING COMMITTEE.

Mr. E. A. Tulian, chairman, reported that the Auditing Committee had examined the books of the Treasurer and found them to be correct. Voted that the report be accepted and placed on file.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Dr. Geo. W. Field, chairman of the committee, presented a resolution extending the thanks of the Society to the Department of Conservation of the State of Louisiana for the excellent entertainment and many courtesies shown the members during the meeting.

President Reighard called for a rising vote, and the resolution was unanimously carried.

*Whereas,* the annual floods have become a source of enormous damage to property, and in many instances, a serious menace to life;

*And whereas,* the progressive drainage of such swamp lands as are by nature directly available for holding back flood waters, contributes in considerable measure to increasing the danger and damage from floods,

*And whereas,* these swamps, in some instances, are natural spawning places and nurseries for fishes of many useful species, and as well the peculiar and necessary breeding places for several species of useful birds, and whereas the drainage of swamp land is often sought merely for local temporary or personal advantage with-

out reference to the public rights, directly or indirectly involved;

*Therefore, be it resolved,* That the American Fisheries Society respectfully urges individuals, associations, state and federal legislators to consider and to safeguard the broad public rights involved.

Approved by vote of the Society.

*Resolved*: That we strenuously urge the passage of a state and federal legislation which may tend to check such existing abuses as the facile pollution of public waters, the waste of valuable young fishes, the use of unnecessarily destructive methods of fishing and wasteful methods of marketing. In many instances, laws already exist, but in the absence of enforcement, due to apathy, ignorance, political consideration, conflict, or lack of authority, the enormous economic waste goes on.

Approved by vote of the Society.

Dr. Field called attention to the death of Captain N. B. Church of Tiverton, R. I., a member of the Society since 1910. Captain Church was practically the first man to apply system and business methods to fishing. He built up a strong organization and did much to develop the fertilizer and oil industries in connection with the menhaden and other fishes. He was always interested in the public welfare, served in the state legislature, besides being one of the notable figures in the history of American fisheries.

A resolution was presented that the Society record its sorrow at the death of Captain Church. This was approved.

### COMMITTEE ON TIME AND PLACE OF MEETING.

Mr. Henry O'Malley, chairman, reported that, after considering the claims of a number of cities, including Chicago, Detroit, Baltimore and Providence, the committee had unanimously voted to recommend the Twin Cities of Minnesota, St. Paul and Minneapolis, and the

date as August 29, 30 and 31, 1917. On motion by Professor Henry B. Ward, seconded by Mr. John P. Woods, the Society unanimously voted to accept the recommendation of the committee.

COMMITTEE ON NOMINATIONS.

Mr. John W. Titcomb, chairman, presented the following list of names for officers of the Society for the year 1916-17:

*President*.....GEORGE W. FIELD, Sharon, Mass.
*Vice-President*.....HENRY O'MALLEY, Washington, D. C.
*Rec. Sec.*.....CARLOS AVERY, St. Paul, Minn.
*Cor. Sec.*.....CHAS. H. TOWNSEND, The Aquarium, N. Y. C.
*Treasurer*.....CHAS. W. WILLARD, Westerly, R. I.
*Editor*.....RAYMOND C. OSBURN, New London, Conn.

*Vice-Presidents of Sections.*

*Fish Culture*.....DWIGHT LYDELL, Comstock Park, Mich.
*Aquatic Biology & Physics*, HENRY B. WARD, Urbana, Ill.
*Commercial Fishing*.....J. F. MOSER, San Francisco, Cal.
*Angling*.....DANIEL B. FEARING, Newport, R. I.
*Protection and Legislation*, GEO. A. LAWYER, Wash., D. C.

*Executive Committee.*

N. R. BULLER, *Chairman*.....Harrisburg, Pa.
H. WHEELER PERCE.....Chicago, Ill.
JOHN N. COBB.....Seattle, Wash.
JOHN P. WOODS.....St. Louis, Mo.
E. W. COBB.....St. Paul, Minn.
JOHN S. PARSONS.....Accomac, Va.
W. N. KEIL.....Tuxedo Park, N. Y.

*Committee on Foreign Relations.*

GEORGE SHIRAS, *Chairman*.....Washington, D. C.
HUGH M. SMITH.....Washington, D. C.
E. E. PRINCE.....Ottawa, Can.
JOHN W. TITCOMB.....Lyndonville, Vt.
CHAS. H. WILSON.....Glen Falls, N. Y.

*Committee on Relations with National and State Governments.*

HENRY B. WARD, *Chairman*.....Urbana, Ill.
WM. C. ADAMS.....Boston, Mass.
M. L. ALEXANDER.....New Orleans, La.
WM. L. FINLEY.....Portland, Ore.
JACOB REIGHARD.....Ann Arbor, Mich.

*Publication Committee.*

RAYMOND C. OSBURN, BASHFORD DEAN, JOHN T. NICHOLS

Before this report was acted on the EXECUTIVE COMMITTEE presented a resolution creating the separate office of Editor, following the suggestion made by the Recording Secretary (see p. 173). *Resolved*: That Article III of the Constitution be, and is hereby amended by striking out the words "an Assistant Recording Secretary" and inserting in lieu thereof the words "an Editor." This was approved by the vote of the Society.

Mr. Daniel B. Fearing then moved that the Secretary cast one ballot for the names proposed by the committee. This was seconded by Prof. Henry B. Ward and the motion carried.

The EXECUTIVE COMMITTEE presented a further resolution: That the resolution passed at the 1913 meeting to pay the Recording Secretary a yearly honorarium of fifty dollars be rescinded and that instead the Treasurer of the American Fisheries Society is hereby directed in future to pay the actual travel expenses of the Recording Secretary to and from, and while in attendance on the annual meeting of the Society.

Moved and carried.

Mr. M. L. Alexander moved a rising vote of thanks to President Reighard and the other officers of the Society for their work during the past year, which was unanimously acted upon.

Mr. Daniel B. Fearing presented a letter from Mr. Charles W. Willard calling attention to the successful work of the Atlantic Tuna Club of Block Island.

READING OF PAPERS.

The business of the Society being attended to, the remaining papers were presented.

*Some of the Laws and Methods for the Protection and Conservation of Louisiana's Fish.* By E. A. Tulian of the State Department of Conservation.

Published in the Transactions for March, 1917, pp. 117-123.

Dr. Geo. W. Field, President-elect of the Society, presented an address dealing with certain conditions influencing commercial methods of marketing fish and fisheries products. He called attention to the vast amount of uncoordinated effort in the commercial fisheries and indicated his belief that the Bureau of Fisheries should have the support of all the people in the effort to bring about the better organization of commercial fisheries methods.

After considerable discussion, Dr. Field presented the following resolution, which was carried by vote of the Society:

*Resolved*: That the President of the American Fisheries Society, with the approval of the Executive Committee, be authorized to take such action as he may deem advisable to secure publicity in matters relating to the fisheries or to effect legislation in the public interest.

*The Fisheries of Chesapeake Bay and the Co-operation of Maryland and Virginia for their Conservation.* By John S. Parsons, Commissioner of Fisheries of Virginia.

This paper appeared in the December, 1916, TRANSACTIONS, pp. 15-25.

After extended discussion of this paper by Mr. S. C. Arthur, Commissioner H. M. Smith, Dr. Geo. W. Field and Mr. John P. Woods, the session adjourned.

*Wednesday Afternoon Session, October* 18, 1916.

The program of papers was continued as follows:

*The Utilization and Preservation of Fresh-Water Mussels.* By Dr. R. E. Coker, U. S. Bureau of Fisheries, Washington, D. C.

Printed in the December, 1916, issue of the TRANSACTIONS, pp. 39-49.

Because of lack of time other papers were read by title, except the President's address entitled:

*The Senses and Learning in Fishes.* By Prof. Jacob Reighard, University of Michigan, Ann Arbor, Mich. (See the present issue of the TRANSACTIONS, pp. 133-170.)

After some discussion by various members, the Forty-sixth Annual Meeting of the Society was finally adjourned.

# In Memoriam

1913
CARL. A. ANDERSON
MANCHESTER, IOWA

1905
D. C. BEAMAN
DENVER, COLORADO

1884
TARLETON H. BEAN
ALBANY, NEW YORK

1910
N. B. CHURCH
TIVERTON, RHODE ISLAND

1908
J. J. GLENNAN
WASHINGTON, D. C.

1916
DAN LYNCH
NEW ORLEANS, LOUISIANA

1892
DANIEL MORRELL
HARTFORD, CONNECTICUT

1913
WALTER I. NEAL
AUGUSTA, MAINE

1910
H. WHEELER PERCE
CHICAGO, ILLINOIS

1914
THOMAS H. STRYKER
ROME, NEW YORK

1899
CHARLES W. WILLARD
WESTERLY, RHODE ISLAND

1915
WILLIS L. WYMAN
PARK RAPIDS, MINNESOTA

## Charles W. Willard

Charles W. Willard, of Westerly, Rhode Island, died suddenly in that city on October 25, 1916,

Mr. Willard was elected a member of the American Fisheries Society in 1899, and was made Treasurer in 1900,—an office in which he served the Society faithfully for more than sixteen years, until his death. During all this time he had never missed attending a single meeting except the last one at New Orleans, when illness prevented him from being present.

In 1894, Mr. Willard was appointed a member of the State Board of Inland Fisheries of Rhode Island, and in 1910, he was elected President of the Board, a position he still occupied at the time of his death. He was also one of the founders and the first President of the Atlantic Tuna Club of Block Island.

He was a trustee of the Mechanics Savings Bank of Westerly, R. I.; a member of Franklin Lodge, No. 20, F. and A. M., and past master of the lodge; a member of Palmer Chapter No. 28, R. A. M.; a member and past eminent commander of Narragansett Commandery No. 27, K. T.; a member of Palestine Temple A. A. O. M. S. of Providence, R. I., and a member of Bowen Lodge No. 30, K. of P.

The esteem in which the man himself was held by his fellow citizens was shown at his funeral when the entire activities of the city ceased for an hour and fifteen minutes while the services were being held.

The American Fisheries Society suffers in Mr. Willard's death the loss of a devoted officer, who for more than sixteen years gave his best energies to the building up and the welfare of its interests.

By DANIEL B. FEARING,
*Newport, R. I.*

# Dr. Tarleton Hoffman Bean

Dr. Bean died at Albany, N. Y., on December 28, 1916, at the age of seventy years, as the result of injuries received in an automobile accident. He was one of the older members of the Society, his membership dating from 1884, and in 1908 he was elected to the presidency of the Society.

In the death of Dr. Tarleton Hoffman Bean, American ichthyology loses one of its brightest ornaments and American science one of its most valuable exponents. He was one of that group of Americans who built up a new branch of scientific research, and one in which American genius has been peculiarly conspicuous. It is therefore especially fitting that one who has been thrown into intimate relations with him, and who has himself been a student along the lines in which Dr. Bean so greatly distinguished himself, should try to tell what he accomplished and show how greatly he will be missed.

The scientific study of the sea and all that therein is, has been especially a field for American effort. The work that was begun by Commodore Matthew F. Maury and Lieutenant John M. Brooke on the physical geography of the ocean, the geology of the sea floor and the causes and courses of the oceanic currents was interrupted by the breaking out of the Civil War, but as soon as peace was restored, it was resumed in the magnificent set of surveys preparatory to the laying of the first Atlantic cable. The deep-sea sounding apparatus devised by Brooke was improved and elaborated by Captain Charles G. Sigsbee, U. S. N., and the explorations made by the various vessels under the direction of the Smithsonian Institution, the National Museum, the Commission of Fish and Fisheries, the Coast and Geodetic Survey, and the U. S. Navy Department, have enabled American scientists to add greatly to the sum of human knowledge of the animal and vegetable life in the sea, the meteor-

ology of the ocean, its winds, currents and other phoenomena. The list of careful, accurate and skillful observers who have made these additions is a just source of pride to our nation, and among the names on this list there is none whose position is more honorable than that of Dr. Bean. Though his work has not been of a sort to attract popular attention there is no one whose work has been of greater scientific and practical value.

Born in Bainbridge, Pennsylvania, he received the degree of M. E. from the State Normal School at Millersville, Pa., in 1866. While still a young man he moved to Washington and became associated with the scientific life of the Capitol. In 1876 he received the degree of M. D. from Columbia (now George Washington) University, and in 1883 that of M. S. from the University of Indiana, but his tastes ran more to science than to the active practice of his profession. He became associated with Professor Spencer F. Baird, the Assistant Secretary of the Smithsonian Institution, who was then filling the newly created post of Commissioner of Fish and Fisheries; Dr. Theodore N. Gill, the famous ichthyologist; Dr. G. Browne Goode, with whom he was to be affiliated in much of his future work, and the others of that group who were making of the new Fish Commission an institution which Professor T. H. Huxley said could not be paralleled in the world. Under these influences the scientist that was to be was formed. In 1878 he was appointed Editor of the Proceedings and Bulletins of the National Museum, and every scientific student knows the value of these publications. In 1880 he became Curator of Fishes in the National Museum, a position that he filled until 1895, when he resigned to become Director of the Aquarium in New York. While connected with the Museum he was also closely associated with the Commission of Fish and Fisheries, editing the Reports and Bulletins from 1889 to 1892, and being Assistant in Charge of the Division of Fish Culture from 1892 to 1895. He was the representative of the Fish Commission in charge of its exhibit at the Chicago Ex-

position in 1893; at the Atlanta Exposition in 1895, and at the Paris Exposition in 1900. He was Chief of the Departments of Fish, Game and Forestry at the St. Louis Expositions of 1902 and 1905. The next year he became State Fish Culturist under the New York Conservation Commission, a position which he filled until his death.

Dr. Bean was a prolific writer. Although most of his writings are on topics connected with fishes and fisheries, they are not confined to them. As far back as in 1886 a Catalogue of Publications of the Smithsonian Institution from its beginning in 1846 to that date, lists fifty-three papers by Dr. Bean, and twenty-five by him and Dr. Goode jointly. In connection with this collaborator, the late Dr. George Browne Goode, Dr. Bean produced in 1896 the classic work, "Oceanic Ichthyology," which is still an authoritative text book though published more than twenty years ago. Other noteworthy products of his pen have been "The Fishes of Great South Bay, L. I.," 1890; "The Fishes of Pennsylvania," 1893; "The Salmon and Salmon Fisheries," 1891; "The Fishes of Long Island," 1902; "The Fishes of Bermuda," 1906 and 1912; several articles in "The Fishery Industries of the United States," edited by Dr. Goode, and many magazine articles and official reports. He was an indefatigable student, and the present writer recalls a vivid picture of him in the library of the Smithsonian Institution, poring over volumes of almost forgotten lore to check up some reference or confirm some quotation. Although he was always anxious to know what his predecessors along some line of investigation had accomplished, much of his profound knowledge of aquatic animals was acquired at first hand by direct and personal observation, and no one can look over a check list of American fishes without being impressed by the number of names credited to him, which shows how many species he was the first to describe.

Though he was a scientific zoologist of high order, there was nothing connected with the fisheries that was foreign to him. He wrote of the methods of taking the

fish and on improved means of curing them. He studied the foods of fishes with a view to determining the most tempting baits for fishermen's use and to gathering information as to the unknown factors that enter into the migrations of sea fishes. In 1873 he and the famous fish culturist, Livingston Stone, started from the Hudson River with a lot of shad fry which they planted in the Sacramento River at Tehama, two hundred and seventy miles from the sea. So successful was this experiment this this splendid food fish has now spread from Mexico to Japan, and has become so abundant that in 1892 they sold in the markets of San Francisco at from two to three cents a pound. The catch has markedly declined since that time, but this has not been due to any factor involving Dr. Bean. As a fish culturist there was hardly his equal in America, and the striking success that has attended the efforts of the U. S. Bureau of Fisheries in the artificial hatching of fish eggs is largely due to his directing skill in the early days of the old Commission.

Foreign countries have recognized his merit most liberally. The late Mikado of Japan gave him the Order of the Rising Sun; France made him a Chevalier of the Legion of Honor and an officer of the Merite Agricole, while the German Kaiser made him a Knight of the Imperial Royal Order of the Red Eagle, besides bestowing on him a magnificent bronze plaque, designed by Professor Breuner of Berlin and cast by H. Goldenbeck & Son, the noted bronze founders of Berlin. Indeed there is scarcely a government on earth that has not honored him in some way.

It is to those who had the pleasure and honor of his personal friendship that the memory of Dr. Bean will be most dear. At no time was his deep learning inaccessible to one who sought it, and the present writer feels a gratitude that cannot be repaid for the way in which Dr. Bean placed his time, his labor and his information at the service of an ignorant beginner in the study of ichthyology. Brilliant as were his public achievements, it is to those with whom he was thrown in private life

that his merits are most apparent, and it is those who will grieve for him most sincerely. He had a charm of personality and a freedom from the intellectual arrogance that mars so many men of learning, that made contact with him a source of exquisite delight, and the one who writes these lines feels that he has lost a friend such as rarely enters into a man's life, and one who will leave a gap that will never be filled.

By CHARLES MINOR BLACKFORD, M.D.,
*Staunton, Va.*

# H. Wheeler Perce

BORN FEBRUARY 27, 1861. DIED JANUARY 6, 1917.

During the past year the American Fisheries Society has lost one of its prominent members and enthusiastic supporters who has often been chosen for positions of responsibility in it and has discharged his duties with more than ordinary zeal and enthusiasm. Mr. Perce was a native of Brooklyn, New York, and the son of Elbert Perce, who was himself a fish fancier and an angler as well as an author and educator. Little wonder then that in rambles along the trout streams of the Catskills the father took the boy who thus early acquired that love of nature and of nature's finest sport which accompanied him through life and developed into the ruling passion in his manhood years. As a boy of nineteen he went to western Kansas and in the romantic role of cowboy learned the wonders of nature as they presented themselves in that marvelous region. But the greater opportunities for success in business lines drew him to Chicago where in 1885 he formed business connections with construction interests which he held to the time of his death.

At the time of the Columbian Exposition Casting Tournament in 1893 he was attracted by this sport and remained closely associated with it from that date. In 1906 the National Association of Scientific Angling Clubs was organized at Kalamazoo, Michigan, and he, elected as its first president, guided the interests of the new organization for five years. He was, however, an ardent advocate of the strictest amateur standing in casting competitions so that in 1913 he withdrew from the original association to form with others the National Amateur Casting Association in the work of which he was active until his death. His bold and uncompromising action on this matter brought criticisms from former associates with different views, but with that loyalty to principle which always manifested itself in his various

lines of work he stood by this principle and the fight won recently approval and recognition at the hands of the National Amateur Athletic Union. At the time of his death Mr. Perce was President of the Garfield Park Amateur Casting Club of Chicago.

In the Illinois Fish and Game Conservation Soceity he held prominent offices at various times and devoted himself unsparingly to the furtherance of its objects. He was an enthusiastic devotee of all measures for the protection and conservation of game and food fishes as well as a thorough student of ichthyology, and an ardent advocate of all measures for the advancement of knowledge regarding fish for both scientific and practical purposes.

In the American Fisheries Society Mr. Perce always displayed the warmest interest. While business kept him many times from actual attendance at its sessions he was constantly working and writing in its behalf to prospective members and in connection with its campaigns for the advancement of fisheries interests. He was known to those who have participated in active work of the Society as a man on whom one could always rely for real help and who never spared time or energy in his immediate compliance with any request which might come to him from any officer in the organization. At the time of his death he was a member of the Executive Committee. He had acted several times as Vice-President in charge of the section on Angling, and he had many times been prominently mentioned for the presidency of the organization, an honor which he surely abundantly deserved and which only his innate modesty prevented him from receiving.

Associated with strong convictions and the vigorous enthusiasm that looked for action and led in the effort to secure prompt and appropriate results, Mr. Perce joined a genial personality that made him a welcome member of any group. His ability as a story-teller and his humor put him at once on a footing of friendship, not only with men, but also with children whom he loved

most dearly and to whom he was always a welcome companion.

To his other gifts Mr. Perce joined musical talent of no mean order. His songs around the campfire will linger always in the memory of those who have been privileged to hear his rich baritone voice sing "The Old Black Bass," and other songs written and sung for entertainment at the meetings of the clubs with which he was connected. He was also a conductor and a composer, and gave freely of his talents when requests came.

One could not do better than close this all too brief sketch with reference to his literary ability, for that was exercised chiefly in the field of nature study and angling with special reference to the fish he loved so well. He contributed articles on such topics as Tournament Casting, Fish Conservation, and Nature Study, both in prose and verse, to numerous publications, and the unfinished poem quoted below, dated January 1, 1917, is suggestive of his recent devotion to the art of fly-tying that led to designing many beautiful specimens of the art which with characteristic generosity were passed on to his friends. One of these flies, the De Carmo, "has proved a most fascinating lure for trout and been duplicated by many fly-tyers." The little poem which follows bears a date only five days before his sudden death from heart disease and is probably the last of his literary productions.

## THE FLY BOX.

Nestled together, rows on rows
With their keen, sharp-pointed toes,
Here a Hare's Ear, there a Glory,
A Royal Coach with a wondrous story.
Wickhams, Fairies, a tiny Dun
That could tell of an hour of glorious fun
At a deep, dark pool, in the shadows dense,
When the heart beat fast and nerves were tense.
And six bright beauties rose and took
Each in his turn that fateful hook.
And I care not whether they're wet or dry,
Fancy or Somber, yea, not I . . . .
I love them all, yes, every fly.

From *Outer's Book*, May, 1917,

By HENRY BALDWIN WARD,
*Urbana, Ill.*